Proposal on Measuring Bubble Formation in Liquid Metals

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Experimental Goals:

- Test the Bubble Evolution model for He in liquid metals
- Benchmark the code at low flux
- Look for bubble effects on H-trapping

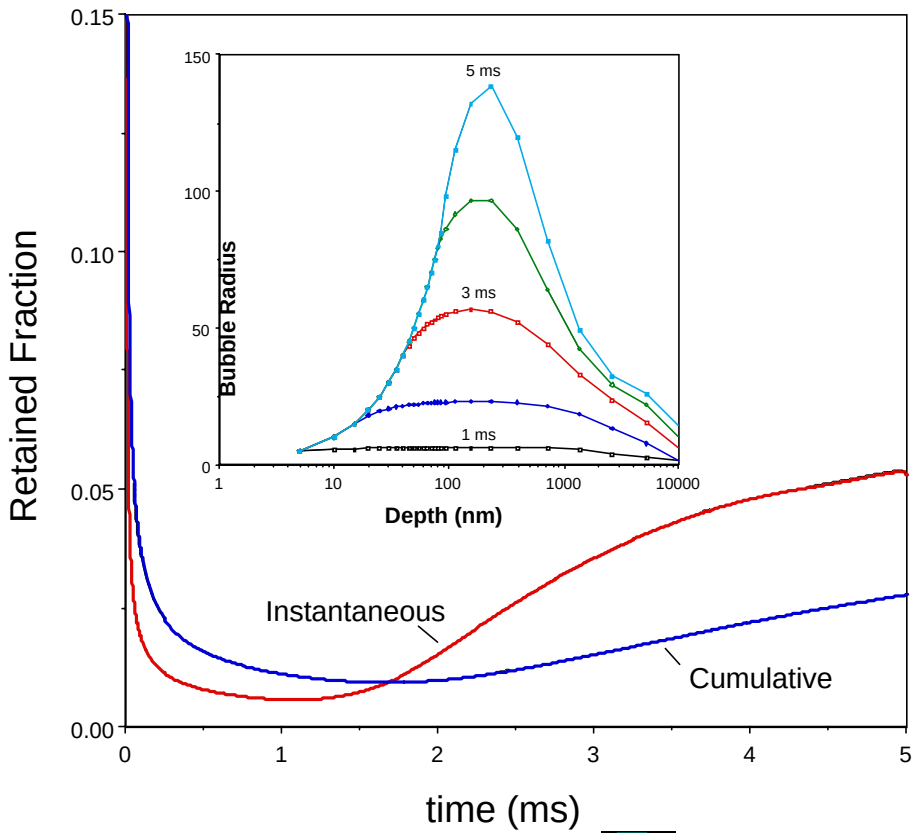
We propose an experiment to quantify the He dynamically retained within the liquid metal.

- Sandia's modified Nano-Bubble Evolution code (NBE-L) predicts:
  Liquid Ga or Sn at 600 K, exposed to a He flux of 10 mA/cm^2,
  will retain 10^{14}-10^{15} He/cm^2 in bubbles within 1-2 μm deep.

- This concentration should be present in steady-state.

- It can be measured
  - by ^{3}He(d,p)^{4}He NRA
  - by He Re-emission.

- If bubbles are not present, the concentration will be low; and measurements will yield the effective He diffusivity.



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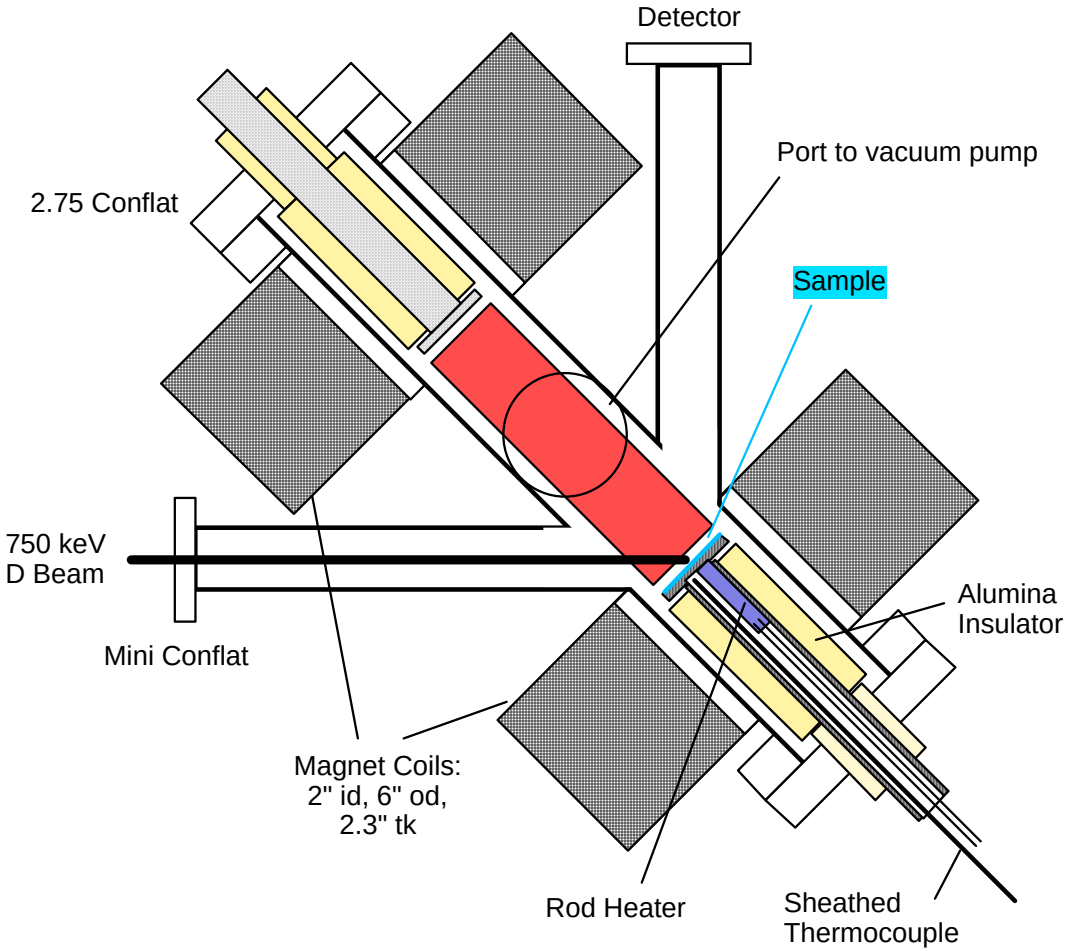
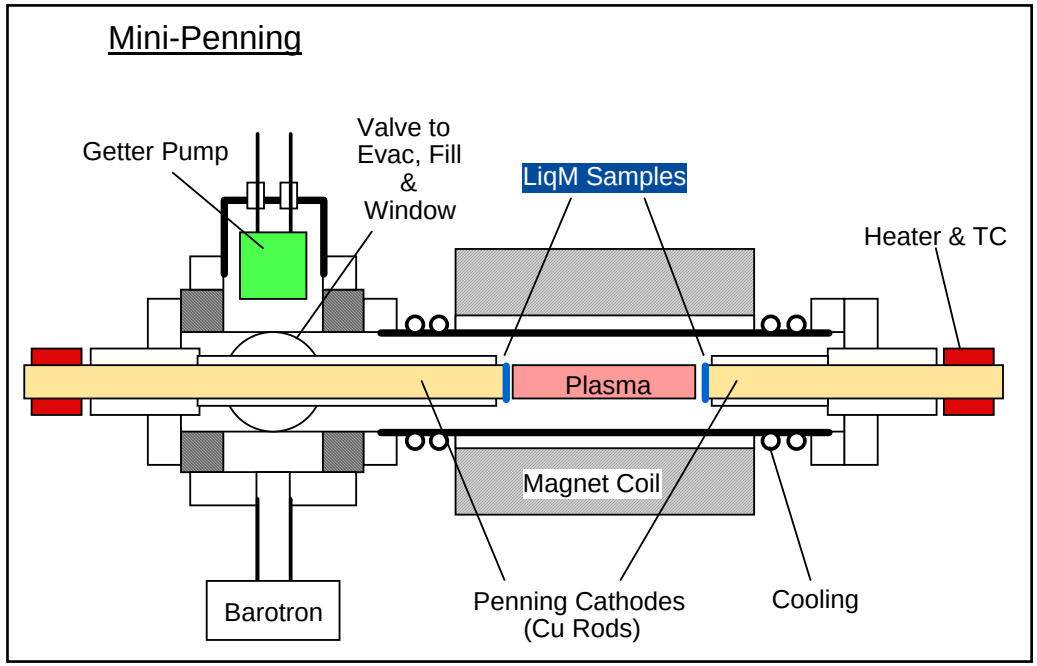
He Depth Profiling Experiments will use SNL-CA's shielded deuteron accelerator facility.



- Penning trap produces flux of 10^{21} He/m^2-s at 1 keV.
- Liquid Ga or Sn (1 cm^2) covers trap (cathode) plate.
- ^{3}He added to plasma is profiled in LiqM by d^+ beam.
- High steady-state retention will signify bubble formation.
- Temperature dependence of retention will be compared with the code.

He Re-emission Experiments will determine the quantity of He in nano-bubbles by desorption.

- It uses a small volume (35 cc), getter-pumped He Penning discharge with Liquid Metal cathodes.
- The discharge is stabilized in steady-state, where
  re-emission rate = implant rate,
  then isolated.
- The quantity of He in the LiqM is determined from the pressure rise after the discharge is terminated.
- Compare liquid with solid.



Quantity in film ≈ 5×10^{14} He
Quantity in gas phase ≈ 1×10^{16} He
$\Delta P/P \approx .05$
Barotron sensitivity, $\Delta P/P = .0001$

Equipment and funding requested:

- No new equipment is needed.
  - Magnet and power supplies are available.
  - Penning chamber and electrode assemblies will be fabricated.

- Unique accelerator facility can measure ^{3}He or D.
  - For ^{3}He-^{4}He plasma: ^{3}He conc. and profile by ^{3}He(d,p)^{4}He
  - For He-D plasma: D conc. and profile by D(^{3}He,p)^{4}He
    (Can also examine potential D-trapping in He-filled bubbles.)

- Requested funding for Sandia staff: $30k